The Trail Smelter

Extensive Use of Electrolytic Methods Due to Liberal Research Policy and Available Water Power—Co-ordination of Hydrometallurgical and Smelting Operations Vital Factor in Handling Between Products—Pioneer Work in Electrolytic Zinc Deposition

BY GEORGE J. YOUNG
Western Editor

IN 1911, I visited the Consolidated Mining & Smelting Co.'s smelter at Tadanac, British Columbia. Tadanac is the smelter station. A short distance below the river terrace upon which the smelter is situated and close to the Columbia River is the town of Trail. At the time the principal work was the smelting of lead and copper ores. The lead, obtained by smelting in blast furnaces, was refined by the Betts electrolytic process and cast into merchant pigs. The gold and silver were reduced in a refinery. In addition, copper ores were smelted in blast furnaces, and the matte obtained was shipped to Tacoma. The metal production for 1910 was: gold, 138,901 oz.; silver, 2,017,007 oz.; lead, 33,871,837 lb.; and copper, 5,282,139 lb.; total value, $5,543,574. The plant was excellently managed and the equipment and methods were comparable with those in use elsewhere. In August, 1922, I visited the plant again. Needless to say, the present plant afforded a great contrast with that of 1911.

Initial construction of the Trail smelter began in October, 1895. The smelting company was called the British Columbia Smelting & Refining Co. and the works were described as being on Trail Creek. The first furnace was started in February, 1896, and before the end of the year the plant was in complete operation. The enterprise was established by F. Augustus Heinze. In addition he built a narrow-gage railroad from Trail to Rossland, as the ores from this district were the objective. Heinze also obtained a land grant from the Dominion government to build a railroad from Trail to Vancouver. The end of his Canadian venture came when the Canadian Pacific Railway bought out all of his interests in British Columbia, paying for them, it is stated, $1,200,000.

Equipment for Copper Ores Only, at Start

The equipment of the smelter consisted of a 150-ton sampling mill; a 9x90-ft., double hearth O'Hara roasting furnace; six Herreshoff calciners; four 16x22-ft. reverberatory smelting furnaces; a 40-in. circular water-jacketed blast furnace; and a 38x120-in. water-jacketed blast furnace with removable crucible and forehearth. By the middle of 1896 the plant was smelting from 140 to 160 tons of ore per day. The concentration ratio was 20 to 1. The copper matte was shipped to Butte for further treatment.

The plant was enlarged in 1898 and in 1899 began to treat lead ores in addition to the copper ores. It was enlarged further in 1906. Since then many additions have been made. The electrolytic zinc plant was erected in 1915 and the first zinc produced from it in February, 1916. A sulphuric acid plant was erected in 1916 and also a hydrofluoric acid plant in the same year. The Huntington-Heberlein pots were discarded and Dwight & Lloyd sintering machines put in their place. A copper wire-bar mill was erected in 1921. An addition to the lead electrolytic plant was completed in 1922.

The present plant is equipped to produce electrolytic copper and wire bars; electrolytic lead and hard, or antimonial lead; electrolytic zinc, and zinc dust; fine gold and silver; sulphuric and hydrofluoric acids and copper sulphate. It is one of the most complete metallurgical works in the Americas. At the time I visited the plant in 1922, it was producing merchant lead and zinc, gold and silver, copper sulphate, and sulphuric and hydrofluoric acids. The copper smelting furnaces, copper electrolytic refinery and the wire-bar mill were not in operation, owing to the prevailing copper prices. The metal production from 1907 to 1922, inclusive, is shown in Fig. 1.

Personnel of the Operating Division

Selwyn G. Blaylock is general manager of the company. His staff consists of the following: W. M. Archibald, manager of mines; R. W. Diamond, superintendent of concentration, assisted by W. H. Hannay and C. T. Oughtred; James Buchanan, superintendent of smelters, assisted by G. E. Murray and R. K. Blois; B. A. Stimmel, superintendent of the zinc plant, assisted by F. S. Willis, H. Woodburn and Graham Cruickshank; J. J. Fingland, superintendent of refineries, assisted by H. R. Motherwell; G. F. Chapman, chief engineer in charge of shops and construction, assisted by E. M. Stiles, W. B. Kinnear and M. O'Brien; F. E. Lee, A. L. McCallum, D. G. Bisset and S. Gray are the staff of the research laboratory and G. W. Cotton is chief chemist.

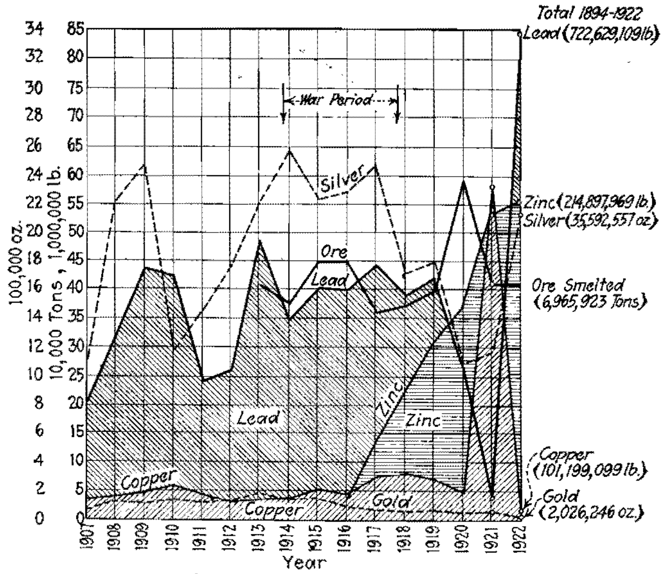


Fig. 1. Metal production of the Consolidated Mining & Smelting Co. of Canada

Practically all of the men upon the staff have been with the company a long time and as a consequence the staff functions excellently. Long experience with the problems of the situation and close association with one another, together with the liberal research policy of the company, has contributed to the development of an exceedingly strong group of men who may be expected to continue their noteworthy work in non-ferrous metallurgy.

A modified Whitely system is being tried out for the handling of all questions relating to the workmen of the plant. A co-operative committee, formed by one man from each department and having a membership of twenty-four, meets directly with the general manager. The committee has initiative in everything pertaining to the labor side of work. It takes full charge of grievances and settles many such problems itself. The plan works excellently. Both the workmen and the management receive first-hand information of labor difficulties. A welfare and safety engineer is part of the organization. This co-operative move has improved the efficiency of the plant materially. A system of performance bonuses has been installed to get workmen to take more interest in their work. It recognizes efficiency in lowering costs and increasing recoveries. The bonuses are based on group costs and recoveries. The bonus is given to a group of men. Repair men are given a bonus which is an average of other bonuses.

Mines of the Consolidated

The Consolidated handled about 385,000 tons of ores from its own mines in 1922 and over 21,000 tons of ores purchased from independent mines. The value of the custom ore in 1922 was $1,194,389, or slightly over 10 per cent of the total production. Thus the Consolidated is in the substantial position of commanding sufficient ores from its own mines for over 80 per cent of its plant capacity. The bulk of the production is derived from the mines at Rossland and the Sullivan mine at Kimberley. The Sullivan mine is noteworthy in having reserves which insure steady production in the future for twenty years or more.

The company owns sixteen mines, of which eleven were operated to a greater or less extent in 1922, substantial production being made, however, from only three during that year. The Rossland group includes the Centre Star, Le Roi, War Eagle, and Iron Mask mines. The 1922 production was 18,566 tons. The Richmond-Eureka mine, at Sandon, made no production. The Sullivan mine, at Kimberley, produced 349,839 tons of zinc-lead ore, 8,926 tons of lead ore and 2,088 tons of pyrite. The Molly Gibson made a small production; Number One, six miles from Ainsworth, made a small production of silver-lead ore; the Highland, 1.5 miles from Ainsworth, also produced a small amount of lead-silver ore and lead concentrates; the Ottawa group in the Slocan City district shipped a small lot of concentrates; the St. Eugene, Lucky Thought, Silver King, Emma, Phœnix Amalgamated, Number Seven and San Poil made no production. The Rock Candy mine, at North Fork, near Granby Forks, produced 4,219 tons of fluorspar concentrates. A limestone quarry on the Kettle Valley railroad, fifty miles from Trail, supplied limestone flux during the year. Data on the mines are given in Table I.

Railroad Situation

Trail is connected with Vancouver by the Kettle Valley railroad, one of the scenic routes of British Columbia. This railroad crosses the Cascades and the Kootenays. Part of the construction is through an exceedingly complex topography. The Great Northern railroad connects Spokane, Rossland, and Nelson. Fernie, which supplies coke and coal, is connected by the Crow's Nest Pass branch of the Canadian Pacific railroad with Kootenay Lake. From Procter, on the lake, railroad connections with Trail are available. Kootenay and Arrow lakes connect with various branch railroads which afford combined water and rail transportation for a comparatively large area of mountainous country. The West Kootenay Power & Light Co., Ltd., a combination of various former power companies and now interrelated with the Consolidated as a subsidiary company, supplies hydro-electric power from its plant at Bonnington Falls. The present power load of the company is in excess of 27,000 hp. A power plant on Bull River supplies electric power to the Sullivan mine, at Kimberley. Increased hydro-electric power development is contemplated.

The situation possesses many advantages. Fundamentally there is a dependable ore supply. Coke and coal supplies are not far distant, although the freight cost is relatively high. Limestone and other necessary fluxes, including siliceous ores, are available. Cheap power, the development of which entailed about $200 per horsepower, is at hand. The country affords further opportunities of developing hydro-electric power. The markets are distant, being principally in eastern Canada and the Orient via Vancouver.

Table I—Development and Production of Mines Owned by the Consolidated

Mine	Total Development Footage, Feet	Total Ores from 1894 to End of 1922, Tons	Ores
Rossland mines	335,334	4,978,260	Gold-copper smelting and concentrating
White Bear	10,382	3,002	Gold-copper
Sullivan	48,699	1,691,587	Zinc-lead, lead, and pyrites
St. Eugene	106,321	1,926,587	Lead and zinc
Molly Gibson (a)	12,181	9,106	Silver-lead
Number One (a)	10,198	24,999	Silver
Highland (a)	19,278	10,234	Lead-silver and lead concentrate
Ottawa (a)	11,626	1,792	Silver ore and concentrates
Lucky Thought	3,490	1,816	Lead-silver and silver-zinc
Richmond Eureka	9,699	19,420	Lead-silver
Silver King (a)	20,462	17,238	Silver-copper
Emma	7,644	262,560	Copper
Phoenix Amalgamated	2,581	2,493	Copper
Number Seven	5,934	7,388	Siliceous gold
Rock Candy	1,884	20,040	Fluorspar and fluorspar concentrates
Coast Copper Co.	6,222	....	....
San Poil (a)	....	18,470	Siliceous gold

(a) Production since company acquired mine; other productions include production under previous owners.

During 1922, the metal product from 407,200 tons of ore amounted to 70,600 tons, or a ratio of 5.76 tons of ore to one ton of metal. This is the outgoing freight which brings revenue to the railroads; ore, coal, coke and supplies constitute the incoming freight. Freight on the company's ores averaged slightly under $1.70 per ton during 1922. Costs at the reduction plant approximated $45.80 per ton of metal produced; sales approximated an average of $127.60 per ton of metal sold and the net annual profit was about $16.30 per ton of metal sold, or $17.40 per ton of metal produced. The foregoing figures are approximate estimates made from the costs and production statistics given in the annual report of the company for 1922.

General Features of the Plant at Tadanac

The smelting plant is upon a high river terrace overlooking the Columbia River. The site is comparatively level. Slag and waste products go over the bluff above the river. All parts of the plant are connected by standard-gage tracks and are served by narrow-gage tracks upon which trolley-type electric locomotives are operated. Water is pumped from the Columbia River and is also flumed from Trail Creek. The plant is divided into four parts: the lead and copper smelting unit, the refinery unit, the zinc unit, and the concentrator. The shops, offices, and warehouses are in close proximity to the smelting and zinc units. Dwellings for some of the officials and accommodations for assistants are provided on the plant site. Most of the workmen live in Trail, which is below the plant on the bank of the river. Like many other smelting plants which have attained a ripe age and which have grown rapidly, the older buildings and parts of the plant contrast with the more recent construction. However, the plant as a whole is convenient and well arranged.

Smelting Unit

The raw-ore supply comes principally from the Sullivan mine and consists of finely divided lead concentrates. This constitutes 90 per cent of the lead ore. A varying amount of lump ore is shipped from the Slocan. The Ainsworth mining division supplies sulphide ores. Copper ores come principally from Rossland in the form of a gold-copper ore; eventually this ore will be concentrated and the copper concentrates will be smelted instead of lump ore. Copper Mountain of the Canada Copper will ship its copper concentrates to Trail when its property is in operation. This property has a modern flotation mill and will ship from 100 to 150 tons of 20 per cent copper concentrates when in operation. The Coast Copper Co., Ltd., at Elk Mountain, Vancouver Island, and the Sunloch Mines, Ltd., at Sooke, B. C., both controlled by the Consolidated, will also supply copper ores.

Lead smelting follows established practice: sintering of the fine ores and smelting of the sinter in blast furnaces. Fig. 2 shows the flow sheet. The Dwight & Lloyd sintering plant consists of six sintering machines; an additional machine was in course of construction at the time of my visit. The raw ore is sent over the first three machines and the resulting sinter is crushed and resintered with the addition of 13 per cent of granulated slag, the lead blast furnace slag being used for the purpose. Wedge roasting furnaces are available for preroasting.

All lead concentrates over 0.25 in. in size are crushed and sampled by Vezin samplers. The limit size for sintering is 0.25 in. Fine concentrates and flotation concentrates are sampled by means of a pipe sampler, or a split shovel, and are placed in the Dwight & Lloyd bins or bedded in separate bins. The limestone used in the sintering mixture is crushed to 0.25 in. size. Lump limestone is added to the blast-furnace charge as required. The first charge sent to the Dwight & Lloyd machines contains 14 per cent sulphur and is discharged at 9 per cent sulphur. The second roast produces a sinter containing under 2 per cent sulphur, usually 1.5 per cent. Due to the double treatment, the sulphur content is often under 1 per cent.

Four lead blast furnaces, 45x180 in., are available. Two were in operation at the time of my visit in 1922. The average tonnage of each is 230 tons per day. The charging is by means of side-dumping cars, which receive the ore from overhead pans into which the charge is weighed from the bins and dumped into the charging cars, which are handled by electric locomotives. The blast-furnace slag is discharged into a forehearth and then to a launder. A siphon tap is used and the usual lead-well arrangement. No matte is made in the lead blast furnaces. The slag is granulated and laundered to waste. Part of the granulated slag is recovered by a centrifugal pump and pumped into a bin to be used in the preparation of the sintering charges. The lead is recovered as blast-furnace bullion and is wheeled in small pots to the 50-ton drossing kettles, where the lead is drossed, the dross going back to the blast furnaces and the lead being cast by a casting machine into anodes, which are transported on special cars to the lead refinery. Cottrell treaters are connected with the Dwight & Lloyd sintering plant and also with the flue system of the blast furnaces. The gases from the lead blast furnaces first pass through a humidifying flue and then to the treater. All of the Cottrell flue dust is reclaimed and forms a part of the charge sent to the Dwight & Lloyd sintering machines.

The lead blast furnace is run on a high-zinc charge. No special trouble is experienced except with accretions in the upper part of the furnace shaft. Bombs are used

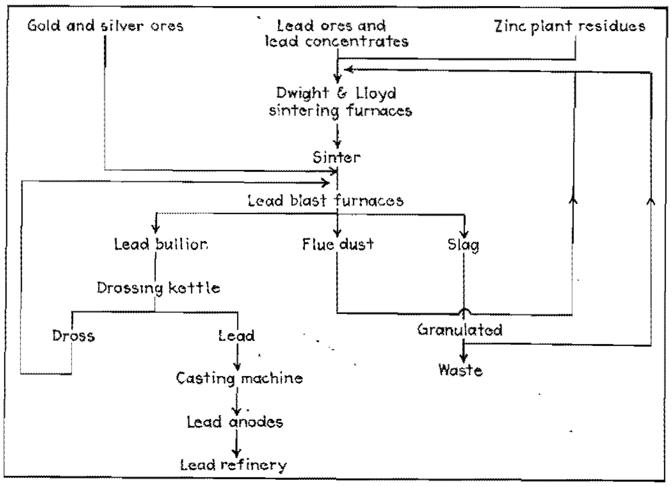


Fig. 2. Flow sheet of the lead-smelting unit

in the lead wells when they show signs of trouble. Once every shift the furnace man introduces into the lead well a half-inch pipe attached to a compressed-air hose carrying air at 60 to 80 lb. pressure. This "air gun" is also used as a bar through the tap hole to stir "things" up. There is usually little trouble at the tuyère line. The blast pressure is 36 oz. Root blowers, direct-driven through flexible couplings and motor, are used. Some of the blowers are driven by belts. Silent chains were tried between motors and blowers, but were discarded.

The type slag used in the lead blast furnaces contains 18 per cent silica, 18 per cent zinc, 31 per cent iron, 9 per cent lime and 1.7 per cent lead. The percentage lead loss is greater with low-lead charges. The tendency is to use high-lead charges which may reach 39 per cent of lead. The ore column is carried from 15 to 19 ft. high. With the high-lead charge, the silver in the slag is about 0.2 oz. per ton; lead 1.7 per cent, sulphur 1.5 per cent, alumina 3 per cent, lime 7.5 per cent, zinc oxide 17.8 per cent, silica 18.6 per cent, and iron 33.5 per cent.

Copper Smelting

Copper ores are first crushed to 4-in. size, sampled in the sampling mill by a Vezin sampler and then trammed to the storage beds. They are recovered from the beds by an underground tunnel. The copper blast furnaces are three in number, 42x420 in. arranged parallel to each other. A forehearth, 9 ft. in diameter, is on the side at the middle of each furnace. The daily charge is 600 tons to each furnace. Only one furnace is operated at a time. The matte is tapped and averages 18 per cent

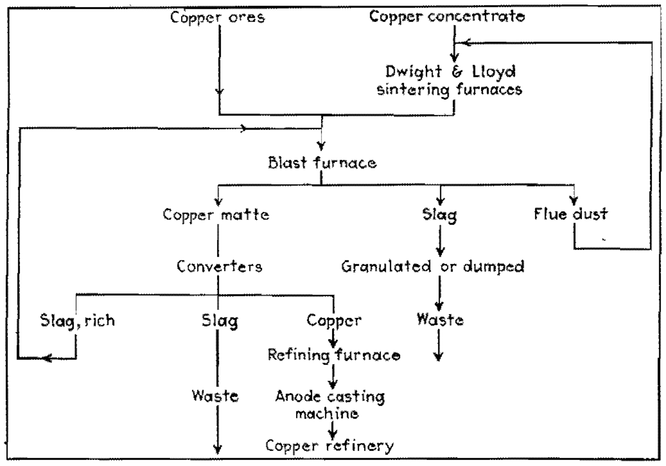


Fig. 3. Flow sheet of the copper-smelting unit

copper. The two converters are close to the furnaces and are served by a traveling crane. They are of the Great Falls type and are equipped with automatic tilting devices and lined with magnesite brick. Siliceous ores and cleanings as well as converter flue dust are smelted with the matte. The matte is blown to blister copper and poured into an anode refining furnace and then cast into anodes by a circular casting machine. The anodes are transported to the near-by refinery. The converter slag is returned to the blast furnaces for cleaning. A Cottrell treater is installed in the flue system of the converters, but no treater is used for the gases from the blast furnace flues, which are equipped with the ordinary facilities for retrieving a portion of the flue dust.

The blast pressure is 36 oz. The slag approximates the following composition: silica 42.2 per cent, iron 17.6 per cent, alumina 10.4 per cent, lime 15.9 per cent, and magnesia 3 per cent. Dwight & Lloyd sintering machines are used for desulphurizing copper concentrates when roasting is necessary. The furnaces are charged by running the charge cars into the furnace from the end. Each charge car is provided with wheels on the upper edges, which engage with a track within the furnace running parallel with the length. The charge cars are gable-end and side-dumping, the side doors being tipped from openings alongside of the furnace. The flow-sheet of the copper-smelting unit is shown in Fig. 3.

The Zinc Plant

The zinc plant has an output of 85 tons per day under the usual operating conditions, but this can be brought up to 100 tons per day. The improvements made in selective flotation at the concentrator, resulting in the production of a high-grade zinc concentrate, are of great importance, as there is less iron to be sent to the roasters. Consequently the iron is easier to oxidize thoroughly and there is less iron to be precipitated from the solution.

The calcine is produced by thirteen standard seven-hearth Wedge roasters arranged in two buildings separated by a brick flue. Two additional Wedge roasters were added recently to take care of custom zinc ores. A drying and ball-mill unit is provided for concentrates which require preliminary grinding. The sulphur content of the calcine is kept within a maximum limit of 0.75 per cent. The first hearth of each furnace is used as a drier; the fifth hearth is maintained at a temperature of 1,200 deg. F. by pyrometric control; the sixth hearth is maintained at 1,350 deg. F. A variation of 100 deg. up or down produces a noticeable difference in the composition of the calcine and requires immediate correction. The roasters are coal fired on both the fifth and sixth hearths by combustion chambers placed on opposite sides of the roaster. The capacity of each roaster is 40 or more tons per day. The calcine is delivered by worm conveyors to a bucket elevator and received in steel hoppers.

The object of the solution treatment of the calcine is to dissolve the zinc and to produce as pure an electrolyte as possible, free from metals electro-negative to zinc. Arsenic, cadmium, copper, and antimony must therefore be removed from the solution. The iron in the calcine must be present as ferric oxide so far as possible.

The calcine is fed into a series of four 10x30-ft. Pachuca agitators (primary agitation; acid neutralization), together with the solution resulting from the acid treatment and about 10 per cent of the spent acid electrolyte, or tailing solution from the electrolytic cells. The pulp is passed successively through the Pachucas, the final pulp flow going to two Dorr classifiers in series, the sand from the first classifier being re-treated in the second; the overflow is received in a 40-ft. Dorr thickener; the final sand is pumped by centrifugals to four 10x30-ft. Pachuca agitators (*A* in Fig. 4), where it is treated with the remaining 90 per cent of the spent acid electrolyte. The Dorr thickener is used as a surge tank to feed four 40-ft. and three 32-ft. thickeners, the underflow of which is sent to the secondary Pachucas (*A*), and the overflow to the third group of Pachucas,

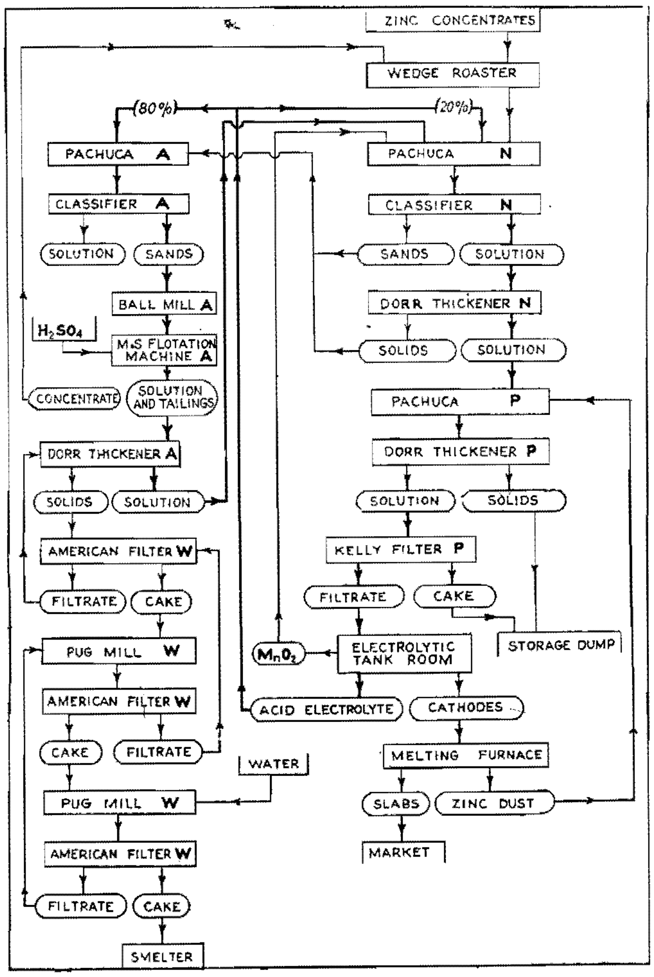


Fig. 4. Flow sheet of the zinc calcine solution treatment. A, acid solutions; N, neutral solutions; P, purification of neutral zinc sulphate solution; W, water.

three 8x20 ft. (*P*). The zinc solution at this stage is neutral. Zinc dust, sufficient to precipitate the copper, cadmium, and the remaining traces of arsenic and antimony, is added to the first Pachuca in the series. The final flow is received by a 23-ft. thickener; the underflow is delivered to the storage dump; the overflow is filtered by seven Kelly filters and the filtrate is pumped to the electrolyte storage tanks which supply the electrolytic cells. The cake from the filters is delivered to the storage dump. The electrolyte contains 60 gm. of zinc, 0.02 gm. of iron and 0.005 gm. of copper per liter.

The treatment in the secondary Pachucas (*A*) is as follows: The flow from the last Pachuca in the series, after acid treatment, is divided between two Dorr classifiers in series, the sand from the first being re-treated in the second; the sand is fed to a 6x6-ft. ball mill, the discharge of which and the classifier overflow being separately fed to 8-cell M. S. flotation machines which recover any zinc sulphide remaining. About 35 tons of zinc concentrate, containing about 41 per cent zinc, is obtained after thickening and filtration on a 12x12-ft. Oliver filter. The concentrate is returned to one of the 25-ft. Wedge roasters. The tailings from the flotation machines and the Oliver filtrate are distributed in parallel to seven 40-ft. thickeners; the acid overflow is returned to the primary Pachucas as acid solution; the underflow, containing soluble zinc, is washed by three American filters and two pug mills in series; the first filtrate is returned to the feed launder of the thickeners; the filtrate from the third filter is used in the first pug mill; the filtrate from the second filter is added to the feed of the first; water is used in the second pug mill. The cake from the third filter is dried and sent to the smelter for the recovery of the lead and silver. The flow sheet given by L. W. Chapman is shown in Fig. 4.

The electrolytic cells are grouped in two tank houses, each with its generator room. No. 1 tank house contains 448 cells arranged in fourteen sections of thirty-two tanks each. No. 2 tank room contains 384 tanks arranged in parallel rows of eight double tanks to the row. Each cell contains seventeen anodes and sixteen cathodes. The anodes are cast electrolytic lead, 22x33x 0.25 in.; the cathodes are rolled aluminum sheet 24x36x 0.1 in. L. W. Chapman describes the zinc-room practice and gives details in *Chemical and Metallurgical Engineering*, Vol. 23, p. 227. The only essential detail necessary to add is that the electrolytic cells are now being lined by a mixture of sulphur and sand cast on the sides and bottom of the tank.

The zinc stripped from the cathodes is melted in coal-fired reverberatories and cast into slabs. It is about three nines in purity, 99.999 per cent. No byproducts are made, as the copper and cadmium are small in amount. Sufficient zinc dust to supply the requirements of the zinc-solution plant is made in the zinc-melting room. The dross obtained in melting is treated in a dross drum to remove all of the metal possible and the remainder is placed in a tank and dissolved by spent electrolyte, the resulting solution being treated in the cells. The power consumption required in zinc deposition is 1.45 kw.-hr. per pound of zinc.

Refinery Operations

Both the base bullion and the copper anodes are electrolytically refined. The lead and copper electrolytic refineries are housed in separate buildings. The lead refinery (Betts process) has a capacity of 150 tons of lead, a new addition to the plant having been completed in 1922. The tanks, of which there are 492, are arranged in groups (seven tanks in a row), the electrolyte cascading through the tanks in a given row; the electrolyte enters at the surface and escapes by a bottom overflow. Individual feeds, 1.5-in. hard rubber pipes, are provided for each cascade. Beneath the tank floor is a launder system for handling slime and electrolyte. The problem is to secure a leak-proof tank, as the electrolyte is expensive. The tanks are made of reinforced concrete, the reinforcement being chiefly at the corners. The bottom and sides are 4-in. thick. They are lined with a mixture of oil-asphalt and 20 per cent of sulphur. In the old plant, the tanks are 7.33 ft. long, 2.5 ft. wide, and 3.58 ft. deep (inside dimensions); the new tanks are 8.5x2.5x3.58 ft. The space between tanks in cascade is 5 in. and the drop between cascades is 3 in. The old tanks hold twenty anodes and twenty-one cathodes; the new tanks twenty-four anodes and twenty-five cathodes; the spacing between anodes is 4.125 in. The cathode sheets, 31.5x27 in., are hand-cast on a sloping iron plate and the end rolled on 0.5x1-in. copper bar. The anodes are 29.5x26x1.125 in.; weight is 320 lb. and each anode is in the tank eight days. The anode scrap amounts to 20 per cent. Two crops of cathodes, four days each, are taken. The average current density is 14.5 amperes per sq.ft.; the voltage drop is 0.3 to 0.55, according to the age of anodes and the thickness of adhering slime. The electrolyte contains 10 per cent hydrofluosilicic acid and from 6 to 7 per cent lead, and is used at a temperature not exceeding 37 deg. C. The slime adheres to the anode throughout electrolysis; the neutral salt, lead fluosilicate, concentrates in the electrolyte. The electrolyte does not require purification. It contains small amounts of tin, nickel and bismuth.

The slime is removed from the anode by hand scrubbing and washing with electrolyte; it is then transferred by gravity to stationary vacuum filters and washed, first with dilute hydrofluosilicic acid and then with water until it is free from lead fluosilicate; the washings of working strength are returned to the tanks as electrolyte; weak wash is re-used until it reaches the proper strength. The new equipment in the slime recovery includes filter presses for quick washing in conjunction with the vacuum filters.

The electrolyte is handled in hard-rubber pipes; the valves are of hard rubber; copper pumps and plungers are used for elevating the electrolyte. "P. & B." roofing paint and asphalt is used for lining all of the launders and protecting the tanks from leakage. The flow sheet of the refinery is given in Fig. 5.

The cathodes after washing are melted in 60-ton kettles; the melting period is eight hours; this is followed by heating up gradually for an eight-hour period and

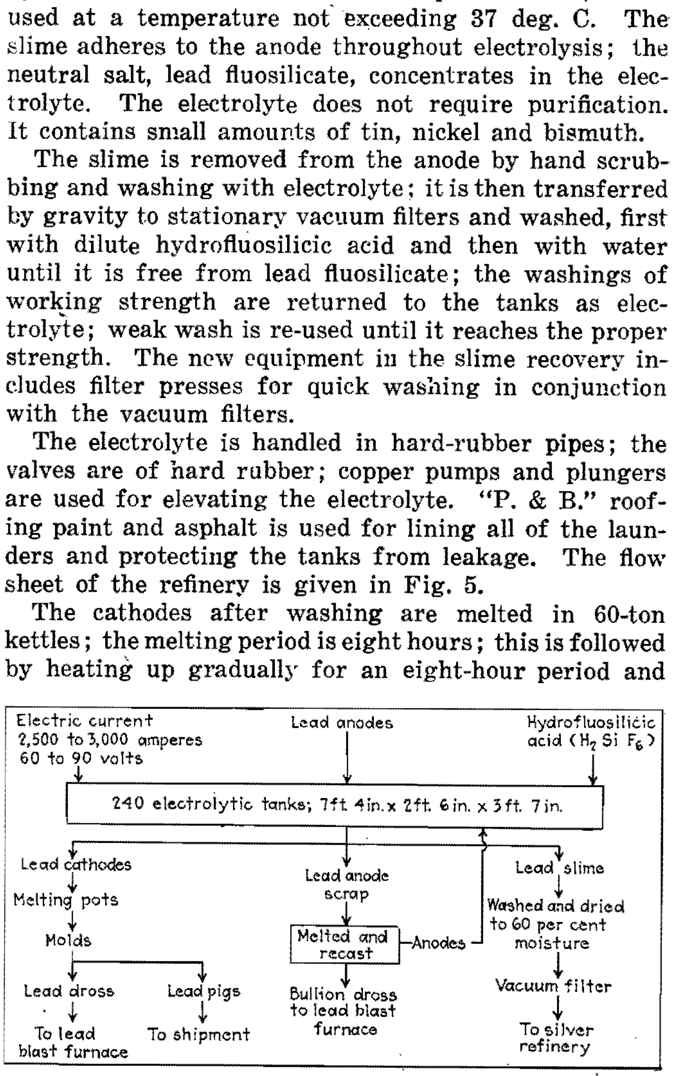


Fig. 5. Flow sheet of lead electrolytic plant

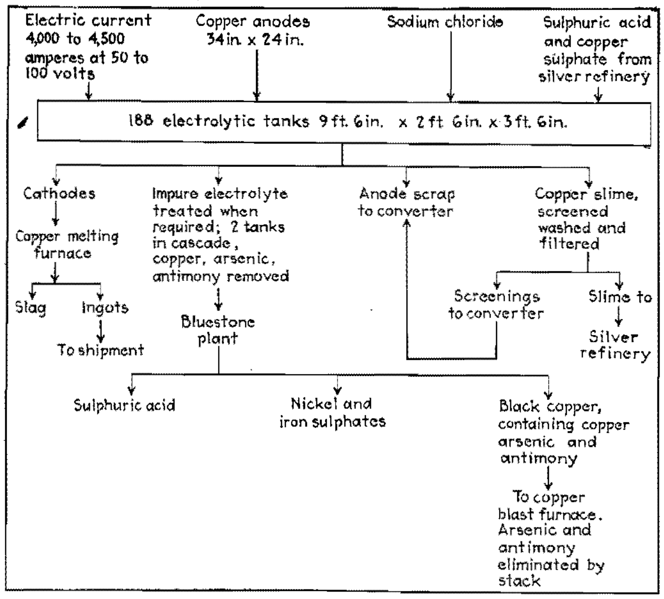


Fig. 6. Flow sheet of copper electrolytic plant

then the molten lead is air-poled fifteen to twenty-five minutes to remove the small amount of antimony; in the third eight-hour period the lead is cast in stationary molds placed in a ring around the kettle. No. 3 Rumsey pumps are used to pump the lead into the central cup which feeds the lead launder. The pigs are skimmed free from dross and loaded upon trucks, thirty-two pigs to the truck, and transferred to cars for shipment.

The copper refinery is in a steel concrete building and the equipment and practice are similar to that of most copper refinery plants. The flow sheet is given in Fig. 6.

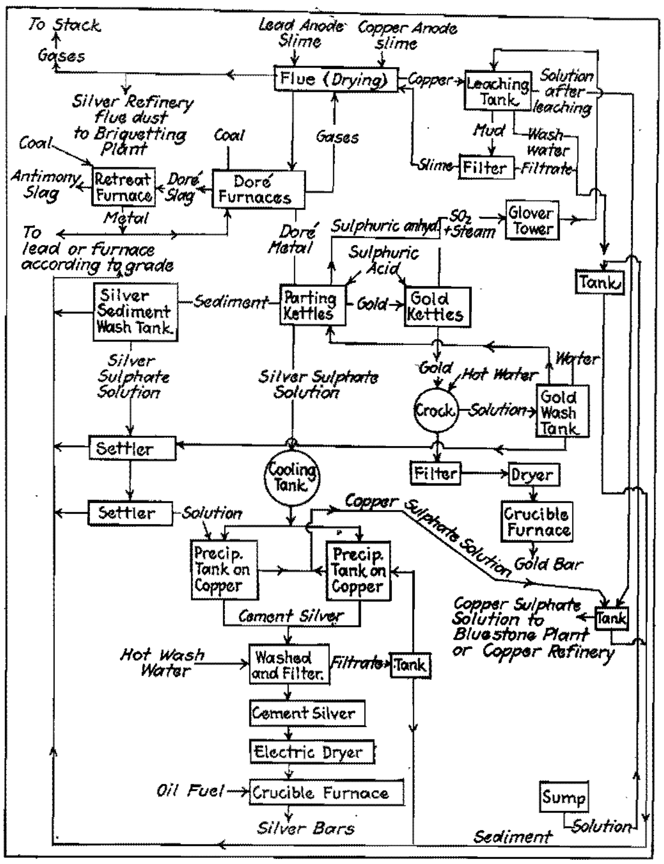


Fig. 7. Flow sheet of gold and silver refinery

The gold and silver refinery is in a separate building close to the electrolytic copper and lead buildings. The anode slimes from both plants are received separately and are dried in a special chamber which is a part of the flue system of the reverberatory smelting furnaces. The copper anode slime is leached, after partial roasting in the flue, to remove as much copper as possible. Both lead and copper slimes are smelted to doré metal in small reverberatory furnaces lined with magnesite brick. The slag is re-treated in a second furnace; the antimony is recovered in a lead slag which is reduced and the lead and antimony recovered. The procedure from this point on is typical of most gold and silver refineries. The details of treatment of the doré metal are given in Fig. 7.

Copper sulphate is recovered from the solutions obtained from the silver precipitation and the treatment

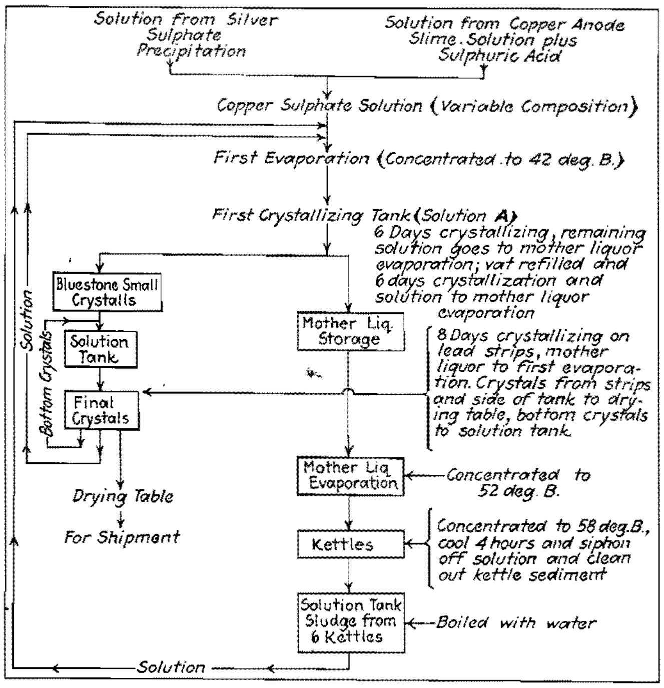


Fig. 8. Flow sheet of bluestone plant

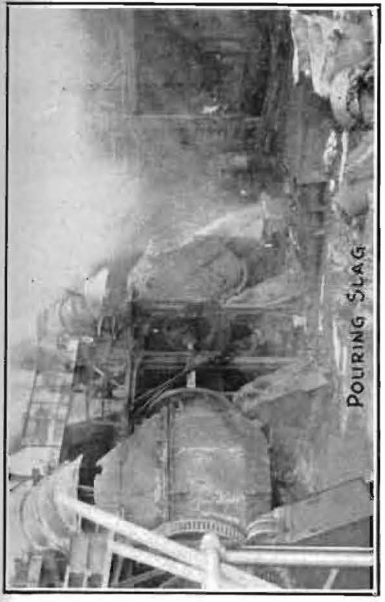
of the copper anode mud. This is done in a separate building not far distant from the gold and silver refinery. The details are given in Fig. 8. Two acid plants are in operation. Six generators are in use in the hydrofluoric acid plant. Each holds a charge of 1,500 lb. of finely ground fluorspar. The generators are horizontal retorts which are charged at the top by means of movable hoppers. The ends of the retort are removed when the spent charge is discharged. This is done by hoeing out the residue, which is in the form of a moderately plastic mass. It is received into cars and hauled to the dump. The acid is absorbed in towers.

The sulphuric acid plant consists of a battery of lump burners which receive pyrite in egg-size pieces. The sulphur dioxide gas is passed over nitrating pots and thence to the lead chambers. The acid plant is relatively small but produces sufficient acid for the hydrofluoric acid plant, the copper electrolytic refinery, the gold and silver refinery and wherever acid is required in the plant.

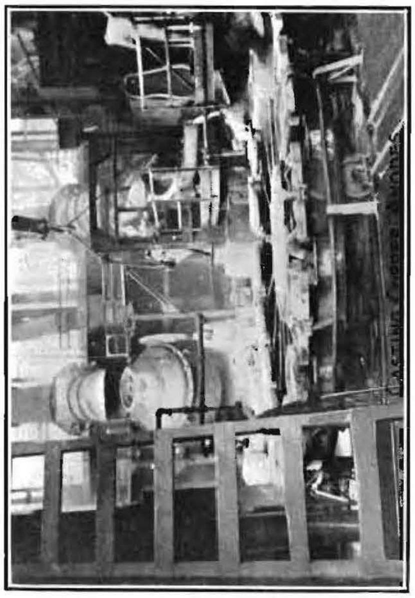
The various smelting, refinery and zinc electrolytic deposition plants form a closed circuit in which the

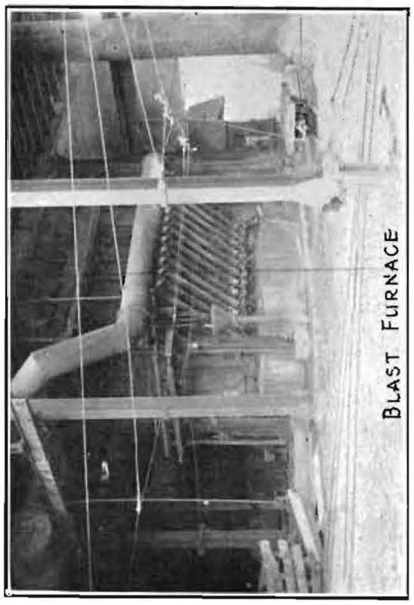

TRAIL SMELTER

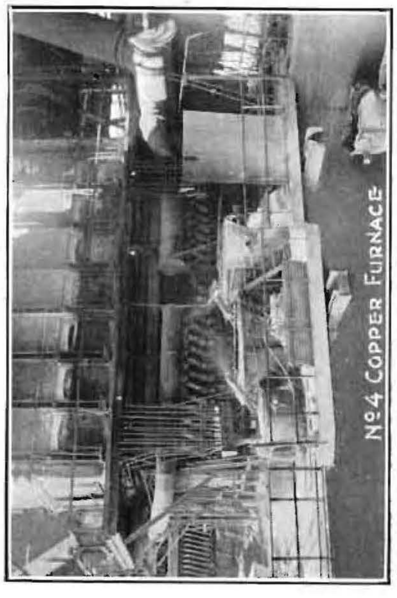

CHARGING CONVERTERS

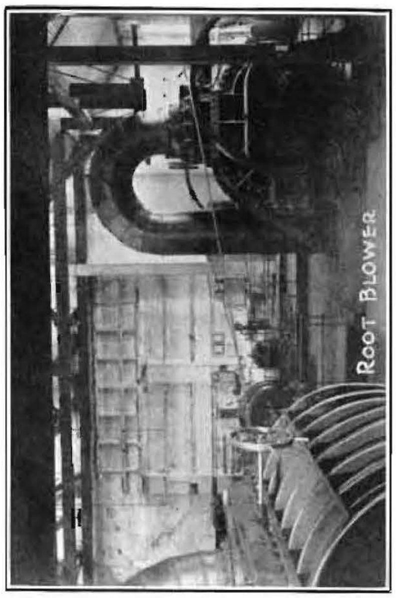

POURING SLAG

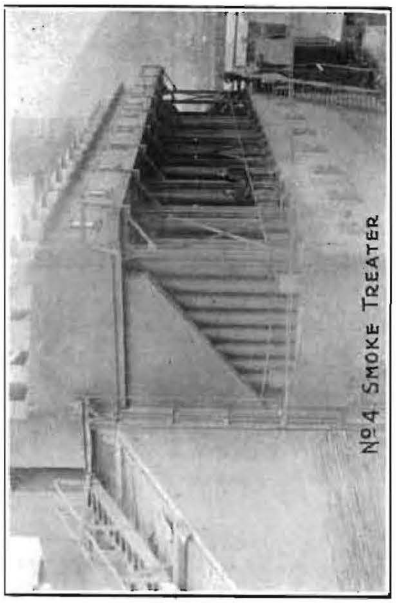

TAPPING MATTE

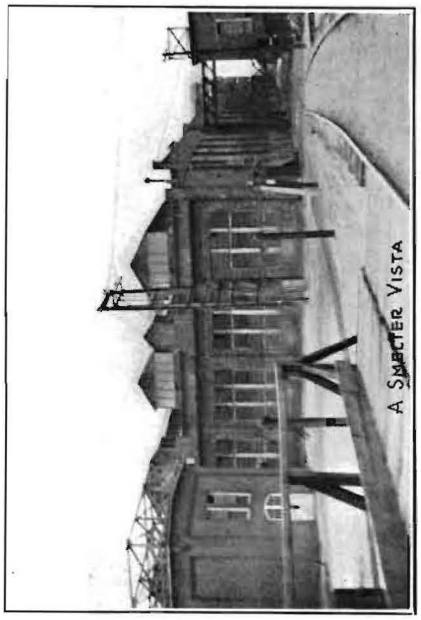

CASTING COPPER ANODES

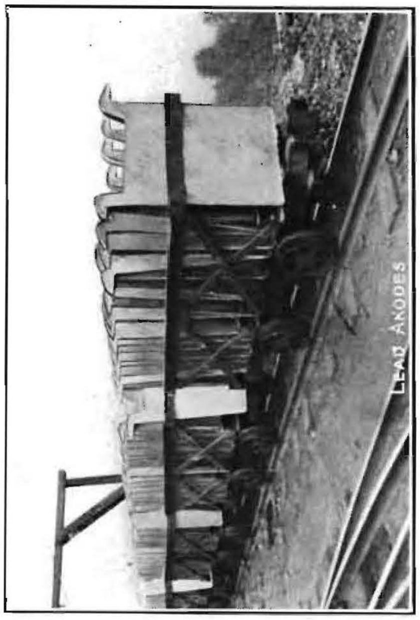

BLAST FURNACE


No 4 COPPER FURNACE

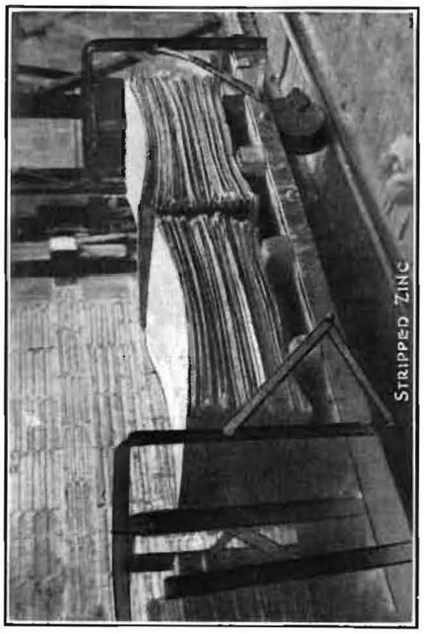

ROOT BLOWER

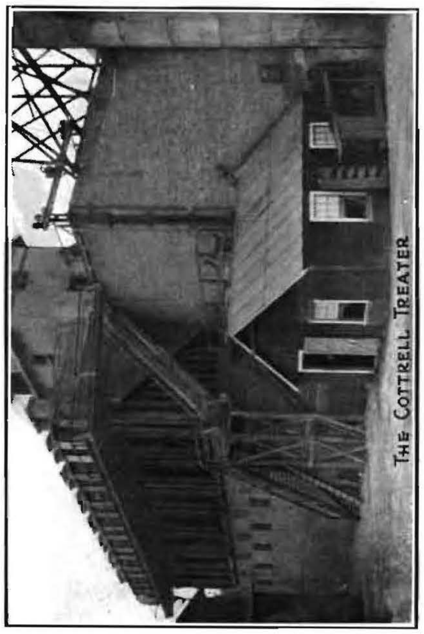

No 4 SMOKE TREATER


A SMELTER VISTA


LEAD ANODES

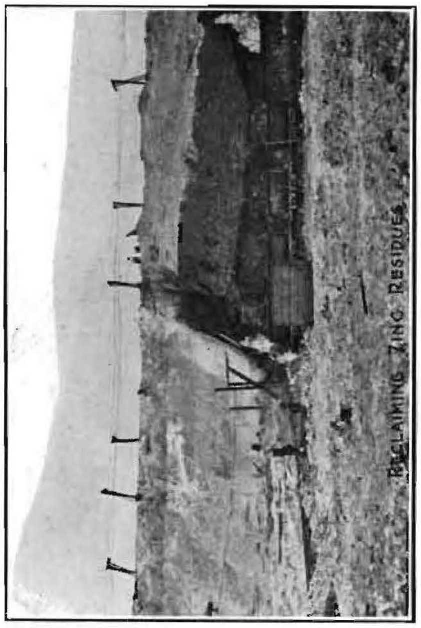

WEDGE ROASTER BUILDINGS


STRIPPED ZINC

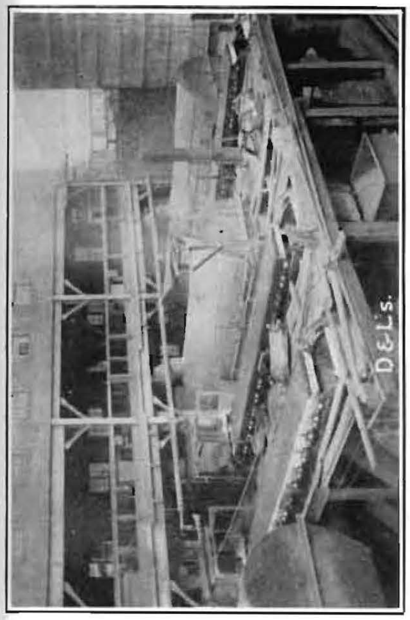

THE COTTRELL TREATER

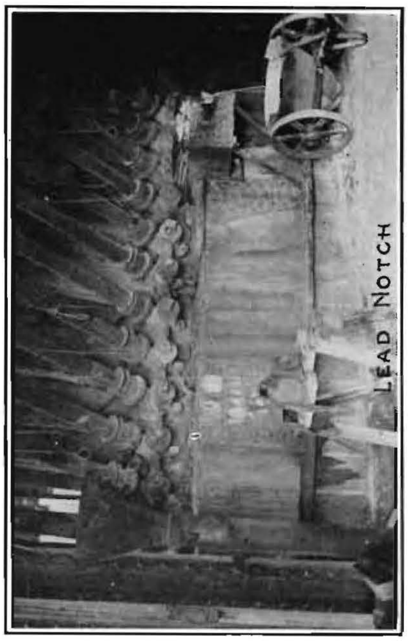

COPPER AND LEAD SLAG PILES

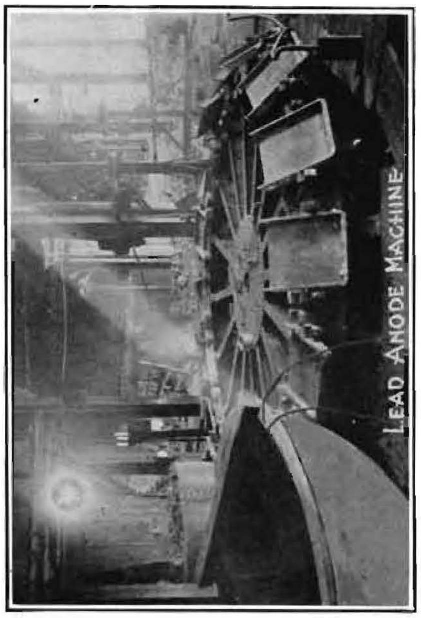

D & L FURNACES

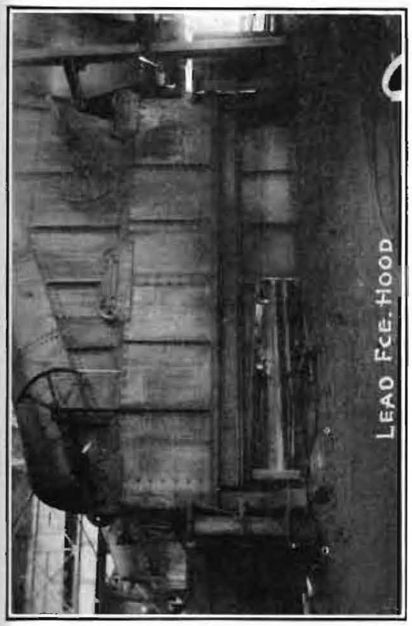

RECLAIMING ZINC RESIDUES


PULLING SPENT CHARGE FROM HYDROFLUORIC ACID RETORTS


D&Ls.


LEAD NOTCH

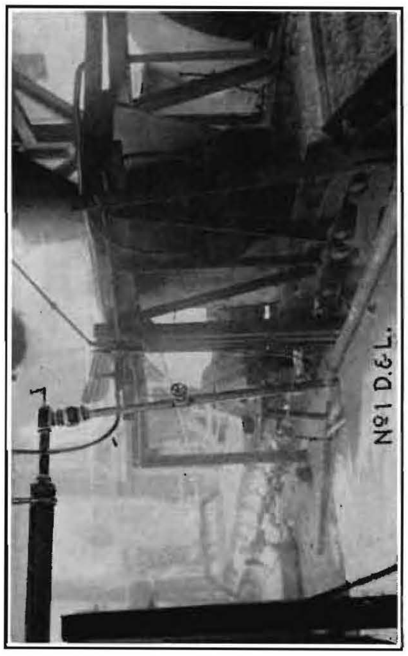

LEAD ANODE MACHINE


LEAD FCE. HOOD

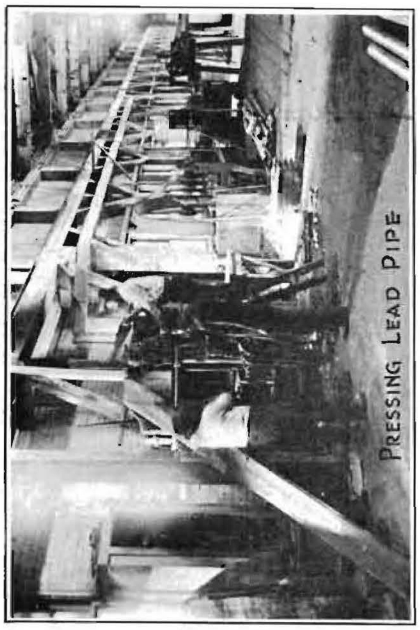

LEAD FCE. SETTLERS

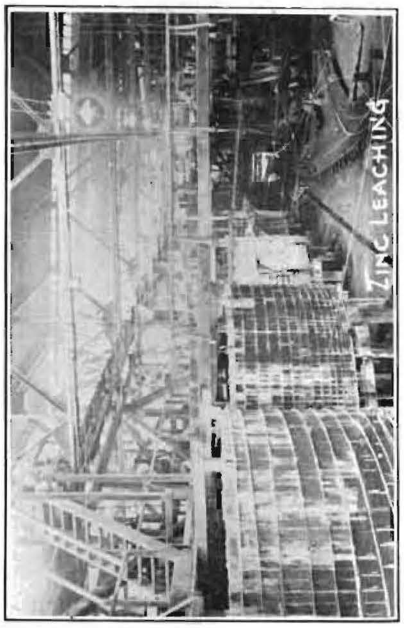

CASTING LEAD PIGS

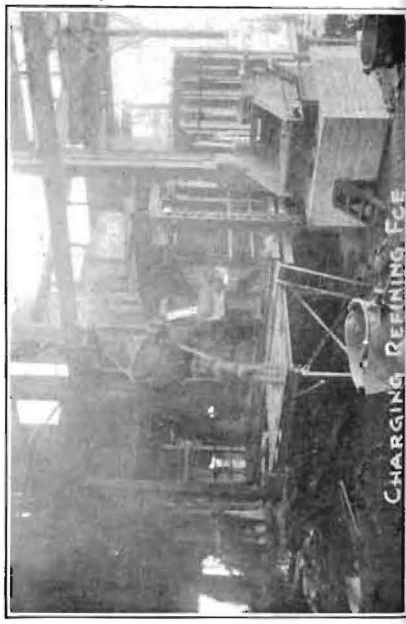

TAPPING LEAD SLAG

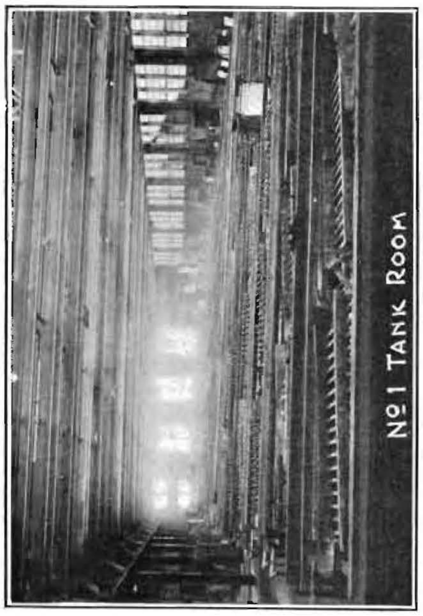

No. 1 D.&L.

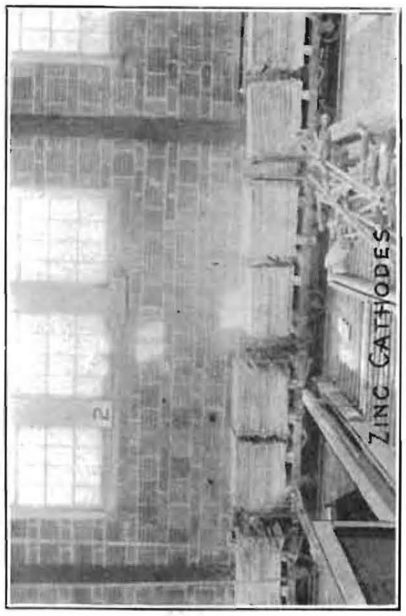

H.&H. POTS

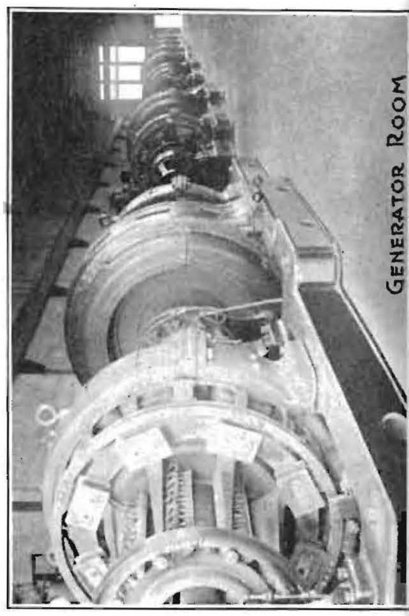

Pressing Lead Pipe

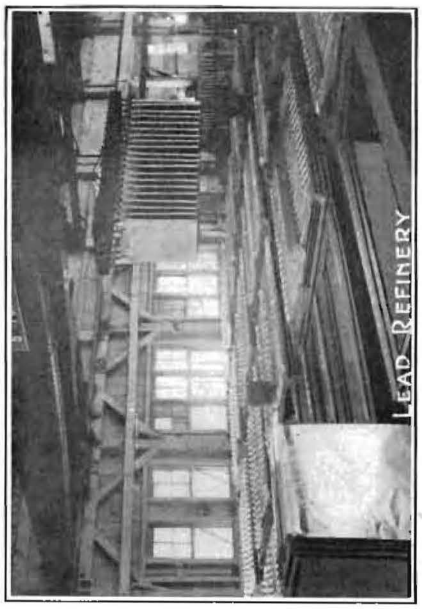

Zinc Leaching

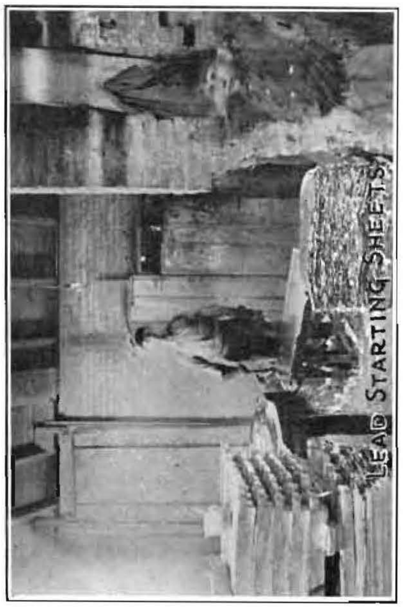

Charging Refining Fce


No 1 Tank Room


Zinc Cathodes


Generator Room


Lead Refinery


Lead Starting Sheets


Poling Zinc

intermediate products are readily handled. The waste products are lead and copper slags, waste gases, and concentrator tailings. The plant is noteworthy for the general use made of Cottrell treaters which handle the gases from the copper converters, the Dwight & Lloyd sintering machines, the zinc-blende roasters and the lead blast furnaces. As with other smelters, the Consolidated has a fume problem; the farmers in the vicinity having started litigation. The company appears to have done all that can be done and the litigation has reached a point where an equitable settlement appears likely.

The smelter is especially well equipped with repair facilities. These consist of a foundry, a machine shop, a forge and plate shop and a woodworking shop. The company undertakes large repair work and makes many of the machines and appliances used in its operations. Much of the success of the company is due to the maintenance of a research laboratory and the development of a staff of research men who are given both facilities and incentive to investigate the technical problems that arise.

The courtesy that Mr. Blaylock and his assistants extended to me is acknowledged. The company maintains a broad policy and shares the results of its experiences with technical men in a liberal spirit.

Mining Along the Alaska Railroad

The Alaska Railroad, on which the last piece of steel has recently been laid to complete the line from Seward to Fairbanks, traverses a region rich in mineral wealth, says the U. S. Geological Survey. The new railroad directly serves the mining interests of Kenai Peninsula, the Susitna and Matanuska valleys, and the central part of the Yukon basin, and will also improve the accessibility of the entire Yukon basin. The mines of the vast inland region of Alaska that is now directly or indirectly served by the railroad have, under the primitive conditions of transportation that have existed in the past, produced minerals worth $150,000,000.

In 1922 the territory immediately tributary to the railroad produced $2,034,210 worth of gold, silver, coal, and a little lead, copper, and tin. Indirectly the railroad serves a much larger mining region, which in 1922 produced over $3,000,000 worth of minerals.

On leaving the coast the railroad traverses Kenai Peninsula, where gold mining has been going on in a small way for twenty-eight years. At Anchorage it is only a short distance from the Willow Creek lode district, which in the last decade has produced over $2,000,000 worth of gold. A branch line provides transportation for the high-grade coals of the Matanuska field. The production of coal in this field has already had a stimulating effect on the development of other mining districts. The Yentna placer district, which produced by hydraulic and dredge mining $223,000 worth of gold in 1922, is accessible by a 60-mile wagon road from Talkeetna station. Between Anchorage and Broad Pass there are undeveloped copper deposits within 10 to 20 miles of the railroad.

The railroad also traverses the western margin of the large Nenana lignite field, whose lignitic coal reserves are estimated at over 9,000,000,000 tons. This field is the chief source of fuel for the great inland region of Alaska, and its development, because of the railroad construction, has already stimulated placer mining in the near-by districts.

About 60 miles west of the railroad lies the Kantishna district, where placer mining in a small way has long been practiced.

The district around Fairbanks, the railroad terminus, has since the discovery of gold there in 1903 produced $73,686,976 worth of minerals, chiefly from the placer mines. Lode mining in a small way has been going on since 1910, but has been hampered by the high cost of transportation and the lack of coal. This situation has been changed by the building of the railroad. In 1922 the Fairbanks district produced $752,273 worth of minerals, and mining is now on the increase. Tungsten, antimony, and silver-lead lodes, as well as gold, have been mined in this district.

There are also a number of small placer districts directly tributary to the railroad, including the Valdez Creek district east of Broad Pass; the Bonnifield district, traversed by the railroad; and the Hot Springs and Tolovana districts, accessible by boat and wagon road from Fairbanks. The Hot Springs district contains tin deposits of promise.

Tin Mining Prospered in Federated Malay States During 1922

C. E. Greig, acting Senior Warden of Mines, Federated Malay States, in his annual report states: "The gradual rise in the tin price, combined with a considerable rise in that of rubber and the general recovery of trade, especially in America, all tended to make conditions at the end of 1922 very different from those at the end of 1921. The price of tin at the end of the year was satisfactory, and it is hoped, for the sake of the stability of the industry, that no great movements in the price will occur. Increased price above a certain figure will lead to increased costs all round."

The labor force employed on mining at the end of the year was 82,195, compared with 86,339 in 1921. About 90 per cent of the employees were Chinese. Labor was cheap and plentiful. The total acreage alienated for tin mining, exclusive of unsurveyed concessions, was 216,561 acres, a decrease of 2,878 acres compared with 1921. The consumption of fuel by the industry amounted approximately to 103,916 tons of coal, 2,640 tons of oil, and 701,137 tons of firewood. Fuel was fairly easily obtained, and the prices ruling for coal were considerably lower, and prices for wood were level with those of 1921. Thirty-four prospecting licenses covering an area of 42,142 acres were issued, but only 458 acres were selected.

The proportion of the total output from lode mining was 6.8 per cent for the year under review, compared with 5.6 per cent in 1921 and 9.6 per cent in 1920. As in former years the bulk of the output from lode mining came from one mine, that of the Pahang Consolidated Co., Ltd., at Sungei Lembing.

Bucket dredges accounted for 15.2 per cent of the total output, this figure showing a slight increase over that for the previous year. At the end of the year there were thirty-three dredges in operation and nine under construction. The number of new dredges proposed to be built in the future, as far as is at present known, is about twenty. More attention is being paid to costs and efficiency in the working of these dredges. Bucket dredging remains the most popular form of mining, but there are indications that the device called the suction-cutter dredge may supplant it.